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ABSTRACT

This paper reports the results of a preliminary study dealing with the ways in which children between ages 6 and 7 organize spoken language. In particular, aspects of the temporal and segmental structure of polysyllabic English words containing the syllable C/jul/, as in the word "pediculous," are dealt with. This study is based on the assumption that the production and perception of spoken language is motivated by phonological units of varying lengths. The importance of peripheral feedback monitoring for speech production in children is re-evaluated, even though there appears to be little supportive evidence for such feedback in existing adult data. To determine under what conditions segmental errors occur in production of words with this particular syllable, a pilot study was run with two six-year olds. From this a stimulus list of four-and five-syllable words containing C/jul/ was developed that was presented orally to seven children. The preliminary results suggest that in order to meet certain phonological conditions, it is the relation between syllable (and not segment) durations which the six-year-old must modify toward the adult duration values. This notion possibly receives some support from the children's use of stress and rhythm strategies. (Author/NCR)

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THE "AMBLIANCE" PHENOMENON: SOME OBSERVATIONS CONCERNING TEMPORAL AND SEQUENTIAL CONSTRAINTS ON SIX-YEAR-OLDS' PHONOLOGICAL PRODUCTION*

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Introduction

In this paper we will report the results of a preliminary study dealing with the ways in which children between 6 and 7 years of age organize spoken language. In particular we will deal with aspects of the temporal and segmental structure of polysyllabic English words containing the syllable C/jul/, as in the word "pediculous". We have assumed that the production and perception of spoken language is motivated by phonological units. These units may be of varying lengths, ranging from single speech sounds through phonological phrases, as evidenced by the work of Öhman, MacNeilage, Lehiste, and many others.

One way to specify phonological units is by referring to their temporal organization. The by-now classical studies of Kozhevnikov and Chistovich (1965) showed that when a speaker repeats the same utterance a number of times, and at the same rate of articulation, the durations of the adjacent phonemes are negatively correlated. Those authors suggested that if the speaker makes an error in the duration of one segment (phoneme) that error will be compensated for in the following segment (phoneme) which will end at some originally planned time in spite of the fact that it started late. They hypothesized that this negative correlation demonstrated that articulatory events are programmed at some specified higher level, not in terms of a single phoneme, but in terms of some higher articulatory unit.

A possible way to discover how large or small these "higher units" may be is to determine the time period over which durational compensation takes place and whether the achievement of such compensation follows any chronological calendar. For present purposes, we assume that any sequence of sounds which is subject to durational compensation constitutes a single articulatory programme.

In a series of interesting experiments, Ohala (1973) demonstrated that such ideas about speech isochrony and programmed units are at least

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questionable in adult data. There are, as yet, few studies dealing with ontogenetic timing control, but the existing studies seem to indicate that temporal control of higher units as demonstrated by adults is not fully apparent in children's productions until eight years of age. In this case we need to reevaluate the importance of peripheral feedback monitoring for speech production in children, even though--as Ohala has shown--there appears to be little supportive evidence for such feedback in existing adult data.

STATEMENT OF THE PROBLEM

It is our supposition that children, possibly up to eight years of age, use a greater degree of peripheral feedback than adults when they speak. If such a notion is correct, then we might expect to see evidence of temporal instability in the child's timing of certain phonological units. Within a word of more than one syllable, such a unit might be manipulated in a number of rule-governed ways, in order to effect either an adult target or an approximation to that target.

We have also sought to bring our data to bear on Stampe's (1973) assertion that:

> "the distinction between processes and rules...is an absolute one, a distinction between constraints which the speaker brings to the language and constraints which the language brings to the speaker..." (p. 73).

In the present case, the combination C/jul/ would be an organization imposed by the English language, while the child's so-called production errors should reflect natural phonological processes which have not been overcome by this language constraint, and which supposedly have the specific purpose of overcoming articulatory difficulties presented by this sequence. Where analysis of substitution data according to processes was supported, the processes were tested against Stampe's claim that they are random, nonlinear, iterative, and frequently optional in their application.

METHOD

The original motivation for examining the C/jul/ syllable arose from our observations of children's mispronunciations of the word "ambulance". We searched a rhyming dictionary to find how many such words occur in English, and discovered well over four hundred polysyllabic words containing this syllable.

To determine under what conditions segmental errors occur in production of words with this particular syllable, we ran a pilot study with two six-year-olds. From this experience we developed a stimulus list of 73 four- and five-syllable words containing C/jul/. In this list we did not attempt to control any segmental parameters: for example initial consonant; vowel-type; presence of affricates, final semi-vowels, etc. The items to be repeated were randomly ordered. Because of the remarkable unfamiliarity of all words (except "ridiculous"),

we considered them to be the equivalent of nonsense words based on English phonotactic rules.

The subjects for the next part of this preliminary investigation were seven boys and four girls between the ages of six and seven years who were considered normal.

Stimuli were presented live voice by CJ under conditions of low ambient noise. Problems that stimulus presentation and response recording presented in data analyses will be enumerated later.

Using IPA, all 73 items were transcribed by one experimenter (CJ) and then randomly checked by the other. In addition, nine items selected for mingographic analysis were transcribed by both experimenters. For measurement purposes, stimuli were processed through a 4-channel Oscillomink, running at a paper speed of 20 mm/sec. Since the methodological problems involved in timing and segmenting speech event both spectrographically and on mingograms are too many and varied to be enumerated here, we would refer you to Naeser, Lisker and Ohala where such problems are very clearly explained.

We should point out that because of: a) the recording environment, b) the fact that stimuli were presented live voice, and c) the great variation in phonetic composition of the 73 stimulus items, we decided to perform analysis only on nine words selected to provide a more highly controlled sample. As may be expected, we are not fortunate enough to glean all 99 items possible (i.e. nine items x eleven subjects). For within this list of 99 items we further eliminated from analysis: (1) all productions in which there were consonantal errors in the first two syllables (although we allowed variations of the vowel sound in the first syllable), (2) any word in which a segment was repeated, for example, "calikikulis". Using all criteria outlined gave a total of 76 usable items (from an original 812 productions) for mingographic analysis. Table 1 shows the conditions met by these response items.

TABLE 1

NINE ITEMS ANALYZED HAD THE FOLLOWING FORM: cvcvcvcvc

SYLLABLE	FORM
1.	C_1: one of /f,k,m/ or /p/
	V_1: one of /ə,I/ or /ju/
2.	C_2: one of /s,l,t,d/ or /n/
	V_2: /I/
3.	C_3: /k/
	V_3: /ju/
4.	C_4: /l/
	V_4: /ə/
	C_5: Either /s/ or /t/

Examples: fasciculous, pediculate

Since acoustic conditions for recording were not ideal, we concentrated our attention on segmentation of the first two and the last two syllables.

RESULTS

Our data revealed some interesting facts. In 110 of 812 items (or 13.5% of the total) the C/jul/ segment correctly matched the adult model. Most of the remaining 702 items which deviate from the adult model fall into a small number of very regular patterns which--for ease of description--we will call "types". The most frequent, with the corresponding number of tokens, are shown in Table 2.

TABLE 2

ERROR TYPES WITH NUMBER OF TOKENS

Type	Examples (stimulus items)	# Tokens	% Total Population
Type 1: /kjul, kjul/	folliculus paniculate	110	13.5%
Type 2: /kjIl, kjəl/	folliculus pediculus	102	12.6%
Type 3: /kil, kIl, kəl/	calyculus paniculate	192	23.6%
Type 4: /kli, klI/	folliculus meticulus	190	23.4%
Type 5: /kl/	fasciculus paniculate	53	6.5%
	Total.....	647	79.6%

79.5% of the data can be categorized according to Types 1-5. Five smaller categories, ranging from eleven to 28 items, account for another 10.3%, leaving a residue of 10.2% more idiosyncratic productions.

In production Type 1, subjects essentially produced the adult utterance. It should be noted that all but 14 of these items were produced by two subjects. One of these subjects, while able to produce the phonological segments correctly, could do so only by stressing the /jul/ syllable. In Type 2, subjects produced utterances which sounded much like the adult production, but modified the vowel preceding /l/ in the /jul/ syllable. In Type 3, /jul/ was replaced with a schwa or high front vowel; the /l/ and final syllable remained intact. In Type 4, /k/ and /l/ formed a cluster, /ju/ was absent and two vowels preceded the final consonant. In Type 5, /k/ and /l/ formed a cluster, /ju/ was absent and only one vowel occurred before the final consonant, giving a three- instead of a four-syllable word. While in this Table we present results from the total corpus of 812 responses, our sample of 77 items chosen for mingographic analysis reflected the same types in virtually the same proportions.

The occurrence of all these types does not appear to be related to: (i) initial consonant; (ii) second vowel; (iii) the consonant preceding /jul/; (iv) the syllable following /jul/ or; (v) whether one or more syllables preceded /jul/. Presence of a nasal or /r/ early in the word was the only factor which influenced results across Ss. For example, "miraculous" was produced by several subjects as /maræ kjurəs/. These results are included in the "Other" category. We would also like to note that 23 of 33 occurrences of /tj/ and eight of 33 occurrences of /dj/ were produced respectively as /tʃ/ and /dʒ/. Where this was done, the resulting CVC could be assigned to our five types in most cases. Eleven examples of /tʃul/ and five of /dʒul/ are included in the "Other" category. We also noted that there was considerable within-subject bias toward a particular form or set of forms.

In the next table we present Types 1-5 in terms of relative syllable duration. It will be noted that for Type 2, the relative

TABLE 3

PERCENTAGE OF TOTAL DURATION MEASURED ON MINGOGRAMS AND OCCUPIED BY SYLLABLES 1 AND 2 (A) AND BY SYLLABLES 3 AND 4 (B)

	$\bar{X}$ TOTAL DURATION	A	B
ADULT	1.894 sec.	43%	57%
TYPE 1: e.g. /kjuləs/	1.918	42%	58%
TYPE 2: e.g. /kjiləs/	1.422	42%	56%
TYPE 3: e.g. /kələs/	1.586	46%	54%
TYPE 4: e.g. /kliəs/	2.006	45%	55%
TYPE 5: e.g. /klIs/	2.464	54%	46%

durations of syllables 1 and 2, and 3 and 4, are at virtually the adult percent values. In this Type, the percent difference of syllables 1 and 2 vs 3 and 4 is probably statistically significant. Types 3 and 4 show a more even distribution of duration across the word, although the percent difference of syllables 1 and 2 vs 3 and 4 are probably also significantly different. For Type 5, we see that syllables 1 and 2 are considerably longer than the same two syllables in the other four types, regardless of the fact that syllables 3 and 4 were reduced to one syllable.

DISCUSSION

We reiterate that these are very preliminary data. However, except for a few consonant cluster studies, we cannot recall any reports of this kind in the child language literature, i.e. reports of production of a particular phonological sequence in a controlled phonetic environment by a number of subjects. Within the limitations of our experiment and its data we offer some speculative observations.

We can say quite confidently that all our subjects could easily produce any one of these segments in isolation. In addition, pilot study results indicated that the whole syllable could be produced when stressed and not embedded in a polysyllabic word. Yet in 702 of 812 cases, the children in our study were unable to produce this particular sequence of segments as presented in the stimulus items. In other words, most of the six- to seven-year-old children could not produce the articulatory states described by the phonemes /StopC,j,u,l/ within the given sequence and time constraints.

In terms of Stampe's theory, the children's substitutions are the result of context-sensitive processes, which respond to complexities of sequences of segments, rather than context-free processes, which respond to inner complexities of segments. Stampe notes that "sequence often requires radical and precise movements of the articulatory organs which are quite difficult in speech of normal "tempo" (1973;23). We would extend this to include the obvious problem it presents a young child dealing with an unfamiliar polysyllabic word. Even using a static articulatory description of tongue position for /j/, /u/, and /l/, we can see that, given a time limit, this sequence might be thought of as difficult.

The next table represents the five most common pronunciation types in terms of one possible process interpretation. In this particular representation the processes are in a feeding order, with the output of each

TABLE 4

ERRORS IN TERMS OF PHONOLOGICAL PROCESSES

Phonological Process	Sample Derivation of "paniculate"
	pənIkjulət
assimilation	pənIkjIlət
coalesence	pənIkilət
metathesis	pənIkliət
coalescence	pənIklIt

process providing input for the next. A sample derivation is provided to illustrate this.

The Type 2 substitution /kjil/ or /kjəl/ can be derived from Type 1, the adult form, by an assimilation process. Here we might conclude that the motivation is to simplify the sequence of elimination of the lip-rounding and/or the extreme and convex tongue position. You can see that this is true of Types 2-4, although in some other types [not here shown] the /u/ is retained. Even allowing that stressed syllables are usually longer than unstressed, and allowing that in these data other effects on duration were randomly distributed, we anticipated on the basis of the adult data that syllables 1 and 2 would be shorter than 3 or 4, as they were. This is of interest since Lehiste has shown for instance that in English, an increase in speech tempo is largely achieved by shortening unstressed syllables, i.e. the duration of stressed syllables decreased at a much smaller rate than the duration of unstressed syllables. We suggest that for Type 2 perhaps a secondary stress somewhere else in the word plus lengthening of final /s/ or delayed release of /t/ leads to the longer duration for syllables 3 and 4.

Another factor that influences the duration of a sound is its position within a higher level phonological unit. It appears that, in some languages, the word as a whole has a certain duration that tends to remain relatively constant, and if the word contains a greater number of segmental sounds, the duration of the segmental sound decreases as their number in the word increases (Lehiste, 1970). While this does not appear to be the case for adult English, we suggest--on the basis of our data--that it would be worthwhile exploring with respect to syllable (as opposed to segmental) timing in children. These notions await further instrumental elaboration.

Type 3, realized as /kəl/, /kɪl/ or /kil/, can be derived from Type 2 by a coalescing process whereby the vowel and vowel-like glide are reduced to one segment. This may be a simple matter of economy, since the combined segments share many of the same properties, but it also avoids the tongue movement of the glide.

We speculate that in at least some instances, articulatory control is achieved by comparing rhythmic constraints, perhaps through equalizing vowel length. It is known, for instance, that for adult speakers, duration of vowels is correlated with tongue height; other factors being equal, a high vowel is shorter than a low vowel. The greater length of low vowels is due to the greater extent of the articulatory movements involved in their production. Subjects in this study tended to the use of: (a) a lax front vowel /ɪ/ or a central vowel /ə/ in first syllable position, (b) the vowel /ɪ/ in syllable-two position and (c) a schwa in final vowel position, i.e. the three vowels tended to be about the same length, subjectwise.

Type 4, which can be /kli/ or /klɪ/, is here derived by metathesizing the vowel and /l/ of Type 3. Here it is not so easy to see the motivation, since the result is a consonant cluster. However, the strong coarticulation tendencies of /l/ are well-known, and this is supported by various examples from our error data, such as /təlækliəm/ for tenaculum, where the /l/ pops up early in the word, and the mistake /fəsɪlsɪklət/

for fasciculate where the /l/ has tried to hop over even the /k/. There has been a claim that, historically, some clusters are equivalent to a single consonant in time and then later are realized as two separate sounds (Gamkrelidze, 1966), and Menyuk (1971) has suggested that for children the /kl/ cluster might best be described as a single element in the underlying phonological representation (although as Fromkin (1971) has shown, this would not be true for adults).

Type 5 is here derived from Type 4 by vowel coalescence which, as above, probably is a case of two processes: assimilation and reduction. This same form could be reproduced by a reduction process acting on Type 3, but we hypothesize the illustrated order in at least some of the cases because the suffix vowel is often a high front one instead of the schwa most often predicted by the adult model. In other words, the coalescence of /kliəm/ might yield /klɪm/, where the reduction of /kələm/ would give /kləm/. Here again we might propose an articulatory motive of simple economy.

We have already suggested that lack of lip rounding may contribute to error types in this instance, despite the fact it is voiced and not voiceless stops which coarticulate more with adjacent phones (Fant, 1969). We speculate that, in those children producing Type 5 forms, lengthening of the first two syllables and coarticulatory effects of /k/ on /l/ are sufficiently strong motivations to pull the two together as a cluster. As a cluster, both consonants would tend to abbreviation, according to Haggard (1973). Precisely why the syllable durations should be so different awaits further investigation.

Only two other processes are needed to explain the subjects' substitutions: The first is deletion, accounting for forms like /ridɪkjuəs/ for ridiculous (28 items). The second is epenthesis, which only shows up in idiosyncratic mistakes such as /pətɪknliəs/ for fasciɨulus.

It appears that our transcription data lend credence to Stampe's notion "that a small number of phonetically transparent processes" used in different combinations can explain an apparent variety of pronunciations. Within the framework of this analysis our data confirm that these processes can apply optionally, randomly, and iteratively. While we cannot demonstrate that they apply in a nonlinear manner, it seems possible that the vowel coalescence processes could operate this way.

SUMMARY

The data presented here do not allow us to make any clear statements either about the organization of higher order units by children, or the extent to which they might use feedback to some central processor to monitor the activity of the articulators. But perhaps some very general points concerning these data can be made.

Our preliminary results lead us to suggest that in order to meet certain phonological conditions, it is the relation between syllable

(and not segment) durations which the six-year-old must modify toward the adult duration values. This notion possibly receives some support from the children's use of stress and rhythm strategies. Thus, as the durations between syllables become established, the child develops a new syllable duration rule which allows a new phonological form, taking the child closer to the adult form. For as Hawkins has noted, although segment duration and traditional age norms for phonemes are in all probability related (since age of acquisition norms are almost invariably for segments), the coarticulation between syllables, particularly those calling for immediately different articulatory activities, may rest in a set of duration values intimately related to what Allen (1975) termed "speech rhythm", a rhythm NOT YET achievable by the child, if only for neurological reasons.

Table 5 illustrates one last comment with respect to process ordering. Here we present the substitutions types used by each subject for the items analyzed instrumentally. If you scan from the upper left to lower right corners, you will notice that the types used by the subjects cluster around that diagonal. While not making any strong claims for this organization, we would like to make several observations: First, most subjects have a preferred strategy for dealing with the /kjul/ sequence; second, we suggest that the first three columns represent the

TABLE 5

ERROR TYPE DISTRIBUTION FOR ITEMS

ANALYZED INSTRUMENTALLY

Error Type	SUBJECTS (RANKED)											
	1	2	3	4	5	6	7	8	9	10	11	TOTAL
Type 1 e.g. /kjul/	6	6						1				13
Type 2 e.g. /kjIl/			4	4	3	1	1					13
Type 3 e.g. /kIl/			3	4	3	5	1		1		1	18
Type 4 e.g. /kli/				1	2		5	7	2	3		20
Type 5 e.g. /kl/						2			1		5	8
Other	1				1	1	1			1		5

most sophisticated /kjul/ subjects and the last subject-column represents the most immature.

Although many substitution forms should be possible from combinations of the processes mentioned, approximately 80% of the data can be

described by three processes simply combined to give our four substitution types. According to Stampe, there is not a natural preference for ordered combinations of processes. While our data appear inconsistent with Stampe's notion, it might also be that by age six, children have learned which strategies (reflected in process combinations and order) their native language prefers. In the latter case, we could interpret this process ordering as part of the rules that the language brings to the learner. In any event, a reasoned and reasonable view of natural processes will have to be tested by further examining not only the limited aspects represented here but, equally as important, by investigating what the perceptual value of the time structure of speech is to children.

Finally, a closing observation. Regardless of the astuteness of our analysis, the /Cjul/ sequence seems to be a phonetic weak spot in the English language, since six-year-olds still can't say it in the phonetic context provided by our stimulus items. What we have presented is one of a number of explanatory possibilities for this verbal behavior.

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